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A TIME SERIES MODEL FOR THE LONG - RUN FORECAST OF PORTS' CONTAINER HANDLING: THE CASE OF THE PORT OF PIRAEUS

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Abstract

The purpose of this study is to investigate the future demand of ports' container handling and to propose a model to forecast this demand using annual data from the Piraeus Port Authority for the period 1980 to 2005. The variables used refer to the GDP, the population of the country, the gross investments of fixed capital of the transport sector, the weighted mean of price of container handling, the unemployment rate, the gross domestic product of the maritime transport sector in current prices, and a dummy variable. The empirical evidence refers to the port of Piraeus; the computations were run using the statistical package SAS and the results are consistent with the theory. The proposed methodology may be used for long run forecasts at any other similar situation.

Keywords: *Time series models, forecasts.*

1. Introduction

Nowadays port competition expands in many different levels. In the long run, a number of ports in their attempt to have unlimited possibilities of growth do not allow their handling to reach the limits of its productive possibilities. In other words, the total allocated offer should always be bigger than the demand (Frankel, 1987). An important rate of its available offer should exist because the port infrastructure (particularly the constant installations, terminals, quays, etc.), cannot be upgraded fast due to high investment costs. Thus, the availability of exaggerating offer in cases of high demand is limited and the ports cannot be further expanded. This phenomenon was particularly intense at the beginning of the '90s (Geraldo Araujo de Souza Junior, Beresford and Pettit 2003) when agreements between port authorities, international transporters and companies–operators worldwide, began to develop in order to improve their participation in the market (Pardalis and Chlomoudis 2002).

In the short run, ports adapt their offer in periods with high demand, by increasing the allocated mechanic means (gantry cranes, straddle carriers, forklifts, etc.). They try to achieve an increase in the productivity of the container terminals because they are in a position to serve the same demand with smaller effort.

In the long run, in order to have greater flexibility in the adaptation of an offer, it is essential to have and operate tools that can provide the possibility of producing sure and accurate forecasts of the future demand. The importance of these forecasts for the port industry is rather significant, supporting port planning and investments (Pardalis 1997). Forecasts of port demand refer to the degree of future handling of containers in all possible levels. These levels are: the size of the containers (20', 40', and others), the type of the containers (dry, liquid, general, and others), the kind of loading/discharged (Lo/Lo, R/Ro, and others), the transportation or not of the goods handled (full, empty), the kind of the goods handled and finally the differentiation in imports/exports and transshipments (Michalopoulos, 2006).

These realized forecasts must have some characteristics in order to become directly useful for the ports. These characteristics refer to: (a) best, (b) accurate, (c) reliable, (d) unbiased, (e) consistent, (f) countable and (g) efficient (Gallaway, Smith, and Paul 1961, Smith 1987).

2. Forecasting methods

Several and considerably different methods are used today for forecasts in container handling. They are distinguished in terms of time and in terms of type of analysis. Time methods are distinguished in short and long run methodologies. Type of analysis methods are distinguished in quantitative and qualitative methodologies. The quantitative methodology is used when historical data are available in order to find trends or relationships between the variables. The qualitative methodology is used when historical data are not available and the analysis is based on information from experts via interviews.

2.1 Quantitative methods of forecast

The quantitative methodology refers to the long run as well as to the short run period. The most common methodology for long run forecasts is the simple regression analysis for demand determination (Pardalis and Michalopoulos 1996). The limitations of these models are that some problems are involved during its specialization which must be solved from the beginning and which sometimes are independent of the general economic theory or especially the theory of port economics. These problems (Intriligator 1982) refer to: (a) heteroscedasticity, (b) collinearity–multicollinearity, and (c) autocorrelation.

Another category of problems is indicated because of the selection of the variables that have been included into the model; the most well known models that are used in this category are: (a) full model fitted, (b) forward selection, (c) backward elimination, (d) stepwise, (e) maximum R^2 improvement, (e) minimum R^2 improvement, (f) R^2 selection, (g) adjusted R^2 selection and (h) Mallows' cp selection

(Mallows 1973, Daniel and Wood 1980).

These regression models use only the Gross Domestic Product (GDP) as an independent variable regardless the limited explanation of models (low R^2) [1]. Models can be in linear, logarithmic, or polynomial (1^{st} or 2^{nd} degree) form. For the quantification of qualitative or external factors (such as strikes, changes of policy, devaluations, etc.), which influence the container handling (Pardalis 1997) the use of a dummy variable may be of great importance (Michalopoulos 1995).

In addition to the regression models the methodology of maximum likelihood of generalized linear models, GLM (West, Harrison, Migon and Helio 1985) can be also used. This methodology is similar to regression models however it has an important limitation because the lack of extended statistical tests during its specification stage leading to a conclusion that is not suitable for evaluation of the demand function (Dinardo and Johnston 1996).

In the short run, time series analysis models are most appropriate. These models are known as: (a) classical time series analysis models and (b) Box – Jenkins methodology models (Thalassinos 1991). Classical time series analysis models refer to: (a) trend, (b) seasonality, (c) circular variations and (d) random variations (Pardalis and Michalopoulos 1994). The forms that are usually used are (Sabrakos 2001):

$$f(t)=\alpha_0+\alpha_1 t+\alpha_2 t^2+\ldots+\alpha_n t^n \quad \textbf{(cumulative form)} \qquad (1)$$

If the time can be specified[2], the following forms can be used[3]:

$$Y_t=\alpha+bt \qquad \textbf{(simple linear form)} \quad (2)$$

$$Y_t=\alpha e^{st} \qquad \textbf{(augmentative form)} \quad (3)$$

$$Y_t=\alpha+bt+ct^2 \quad \textbf{(parabolic form)} \qquad (4)$$

Box – Jenkins methodology (Box and Jenkins 1976) consists of the alternative release of regression models. ARIMA (AutoRegressive Integrated Moving – Average) models use the following stages before they will be used for projection purposes (Thalassinos 1991):

1. Calculation of the autocorrelation function, partial and inverse autocorrelation.
2. Identification of model.
3. Estimation of the parameters.
4. Checking the defined model.

The prerequisite for the implementation of a Box–Jenkins methodology is the stationarity of the time series[4]. Extensions of the ARIMA models lead to SARIMA (seasonal ARIMA) models and the Transfer Function Models, VARMA and MARMA models (Thalassinos 1991). Box–Jenkins methodology composes the "best models" but is advisable only for the short run period (up to 5 years).

Finally, another kind of models is the input–output analysis models (Michalopoulos 2006). According to Leontief a variation of the demand of a commodity is possible to induce variations to the demand of other branches of the economy because it consists of industries with interacting operations and activities. In fact, this kind applies only in the case of the port of Rotterdam (GSM model) for certain commodities of this port[5].

2.2 Qualitative methods of forecast

The expert opinion method and the Delphi method are the most well known methodologies in this category.

The expert opinion method consists of the historical approach in the field of forecasting models and it is based on the informed opinion of experts who are familiar with the examined phenomena. The anticipation surveys methodology is an individual case where the same persons who realize the decisions anticipate their future actions. In general, all the factors relating to forecast are not examined extensively. They follow a typical form of involvement after being weighted and appreciated subjectively from the experts.

The Delphi method is a modern way of expert opinion combined with the opinions of a group of experts. Each expert forms an opinion and his forecasts are presented in a summary statistical form. In continue a procedure of revising the experts' opinion based on a previous summary takes place; this procedure continues up to the point where the group of experts attains unanimity.

3. Applications to forecast the future demand of port container handling

Sun and Bunamo (1973) have developed a model to forecast the market share of the port of New York/ New Jersey into the total American imports and exports, based on the assumption of a constant hinterland. It consists of a linear regression model using dummy variables[6], which measures the relationship of ports' commodities and the country's imports - exports.

A regression model with GDP as an independent variable was used in order to forecast the future container handling demand of the port of Piraeus (Doxiades Offices, 1984). The form of this model was y=a+b(GDP), and the dependent variable y is expressed in tons of cargo; the coefficient of linear determination (R^2) is 0.32, that is probably not acceptable[7].

A method similar to Sun and Bunamo (1973) was developed for a long run forecast of the container handling of the port of Montreal, based on the origin and destination of several types of goods (Dagenais and Martin, 1987). The above method was an extension of Sun and Bunamo model which included the doubt of constant hinterland. Their theory was based on the fact that the port market depends on: (a) the physical distance between port and hinterland, and (b) the distance from competitive ports, calculated in "transportation cost per distance" units. The forecasts of this method were measured in cargo tons for imports and exports per category of cargo.

An alternative method was used to estimate the container handling demand in several trade markets (Far-East, Western Europe, North America, South East Asia, Latin America, Middle East, Oceania, South Asia, Africa, Eastern Europe, Unspecified, Drewry Shipping Consultants, 1991). This method has used economic growth indexes, cargo flows per region, world maritime trade development and the containership fleet growth in relation to the unit cost in USD per teu.

The introduction of Box–Jenkins methodology (ARIMA models) was adopted latter as a sufficient method to forecast the future demand of container handling of the port of Piraeus (Michalopoulos, 1993). The selected model, an ARIMA (0,1,2) with an annual average variation of 0.76% using data from 1990 to 1993 performed quite well.

Another methodology used to evaluate the future container handling demand from import/export ports as well as the transshipments (Pardalis and Michalopoulos, 1996), consist of two types of models; a multivariate regression model for import/export containers and a time series analysis model for the total container handling. The selected model with an annual average variation of 6.34% using data from 1993 to 1998 performed quite well.

In order to forecast the future container handling demand of the Mediterranean ports, multivariate regression models were used (Ocean Shipping Consultants, 1998). Among the independent variables were the GDP of the country, the population of each region and the market share of each Mediterranean port.

A methodology to forecast the future demand per region as well as per Mediterranean port until 2015 was introduced in 2000 by Drewry Shipping Consultants. This methodology constitutes of a regression model for imports/exports and a linear trend for transshipments. The utilization rate (UR)[8] index, the GDP, the gross domestic investments, the unemployment index and the GDP per capita are considered as independent variables.

Probability theory was also used to estimate the future demand of ports' container handling both in imports/exports and transshipments (Pardalis and Michalopoulos, 2003). According to this methodology three main probability distributions have been used in an attempt to estimate the demand of ports' container handling as follows:

1. Distribution of daily arrivals of containerships

- A (k) = P (n ship arrivals per terminal for one day; k = 0 , 1 , ...)

2. Distribution of total containers per ship

- D (j) = P (one containership carried containers of size j; j = 1 , 2 , ...)

3. Distribution of transshipped containers per ship

- T (m ; j) = P (m containers handled from containers sized j; m = 0 , 1 , ... j; j = 1 , 2 , ...)

where: k is the number of containerships arriving at every terminal any day; variable k takes values 0, 1, 2, ... ; j is the number of containers carried from every ship to every terminal; variable j takes positive values 1, 2, ... and m is the number of transshipped containers handled from every ship to every terminal.

By using data from the Greek ports this methodology supports the following results: (a) the number of arrivals of containerships per day, per container terminal, as well as the number of total containers handled (in classes by Sturges[9]), follows the Poisson distribution in accordance to x^2 criterion (Michalopoulos, 1996), (b) the number of transshipped containers (in classes by Sturges) from the total handled containers per ship, per container terminal, follows the Geometric distribution in accordance to x^2 criterion, (c) there is an absolute linear relationship between the first probability of the geometric distribution and the daily number of containership arrivals per container terminal. This relation is expressed by the equation:

$$P_1 = 48{,}25 - 2{,}39\lambda$$

where P_1 is the first probability of the geometric distribution and λ is the average number of containership arrivals per terminal, and (d) for the container terminals the measurement of long run demand for transshipped containers handled is expressed by the equation:

$$P_1 = 47{,}66 - 0{,}0067\, L_{t-1}$$

where P_1 is the first probability of the geometric distribution in period t και L_{t-1} is the total number of containership arrivals in period t-1.

4. Long run container handling forecasts for the port of Piraeus

The generalized linear regression models (GLM) are mainly used for the estimation of the long run container handling forecasts for the port of Piraeus. The main aim under this methodology is to:

1. Establish a model with a number of independent variables, including factors that determine the port' containers handling demand.
2. Find the most accurate relationship that explains the independent variables and the container handling in teu's.

In order to evaluate the model the port of Piraeus has been selected as a case study using annual data for the period 1980 to 2005. The following variables have been included:

- Container handling of the port of Piraeus in teu's (TOTTEU)
- Gross Domestic Product in current prices (AEP)
- Hinterland population (PEOPLE)
- Gross investments of fixed capital of the transport sector (AEPK)
- Weighted mean of the price of container handling (PRICE)
- Unemployment rate (ANERGIA)
- Gross Domestic Product in current prices of the maritime transport sector (AEPT)

All the variables, except TOTTEU, are referred as the main determine factors of demand (Pardalis 1997). In order to find a unitary yearly value of the price of container handling for the port of Piraeus a weighted mean index has been used by the following expression:

$$P_X = \frac{\Sigma P_i T_i}{\Sigma T_i}$$

Where x is the year, P_i is the price of every type of containers, T_i is the demand (in teu's) of every type of containers and i take values from 1 to 5. It was necessary to calculate this expression because the port of Piraeus has 5 different values for container handling depending on the size, the kind, the type, the category and the origin/destination of the containers.

An examination of the residuals has indicated that for some consecutive years (1984-1989) there were large negative residuals. The reasons were: (a) the annual increase of handling fees for containers was 9.7% against 12.2% for the period 1978-1983 and 10.7% for the period 1990-1993, and (b) the governmental income policy (devaluation of the drachma in 1985) which has been explained by a dummy variable that quantifies all the qualitative factors. Its value was 1 for the period 1984-1989 and 0 for the remaining years.

Correlation analysis (Table 1) shows that all the variables are important determinants for the dependent variable because their correlation coefficients with the dependent variable TOTTEU are significant.

The estimated model with all the independent variables was:

TOTTEU=1285655,57+14,75(P)-0,014(AEP)-

0,126(PEOPLE)+945,54(ANERGIA)+0,32(AEPK)-64603,33(DUM)

R^2=0.9690, Cp=7.00, DW=1.686, 1st ord. Aut.= 0.021, F value=72.93.

The characteristics of this model are shown in Table 2. It is clear that even the participation of 2 variables only, may give models with sufficient expression of the dependent variable.

In another case the Mallow's methodology was used in order to find the appropriate number of independent variables. The analysis was done using the SAS package and the necessary program in SAS code was:

```
proc reg data=sasuser.model outest=est;
model totteu=people aep p anergia aepk aeptr dum/ selection=rsquare cp best=4;
run;
proc print data=est;
run;
proc plot data=est;
plot _cp_*_in_='C' _p_*_in_='*' /overlay haxis=0 to 25 by 1
vaxis=0 to 25 by 1 hpos=40 vpos=40;
run;
```

The results of this SAS program appear in Tables 3 and 4 and in Figure 1. The Cp statistic appears as _Cp_, against the number of collected independent variables as _in_. In Figure 1 we observe that _p_ values began from smaller than p+1 values with _p_=2. However they increased when we moved in groups with fewer variables. In p=4 the values of Cp increased quickly showing that a model with 4 independent variables must be sufficient. The differences of Cp values, since collected groups with more variables, are constant, while this difference in _p_=4 which is significantly higher, indicated that the collinearity in the model has been eliminated. In order to test collinearity, autocorrelation and heteroscedasticity the methodology use the following SAS program:

```
proc reg data=sasuser.model;
model totteu= p aepk aeptr dum /vif dw spec acov;
run;
```

Therefore the estimated model was:

$$TOTTEU = 112099 + 17989\,(P) + 0.451\,(AEPK) - 2.423\,(AEPTR) - 50510\,(DUM)$$

$$\qquad\qquad\qquad\qquad (6.763) \qquad (0.147) \qquad (1.668) \qquad (33259)$$

The characteristics of this model are appeared in Table 5.

5. Conclusions

Reviews of several methodologies used for long and short run forecasts of containers' handling have been presented in this article. At the same time a new methodology has been used to estimate the long and the short run container handling demand of the port of Piraeus using real data from the Piraeus Port Authority and macro/ micro economic variables from the statistical service of Greece referring to determined factors of demand.

This effort has an individuality to include all the relevant factors that determine the level of port demand of container handling. Simultaneously the statistical significance of the models has tested in addition to tests for collinearity – multicollinearity, heteroscedasticity, and autocorrelation. The Mallow's method is also use to select the appropriate number of repressors for the models. Another advantage of this methodology is the inclusion of qualitative factors such as strikes, devaluations, etc, by using dummy variables.

The same methodology can be used for any port that handles containers for the estimation of the long run container handling demand for a more efficient strategic planning.

Notes

1. In the Greek Ports planning study, that was executed by Doxiades Offices, models with $R^2 = 0.32$ were accepted, due to the fact that only the GDP was used as an independent variable.
2. Time specification means that there are available annual or any other time period data.
3. In fact the most common form is a simple linear one. Therefore, the simple method is the linear trend.
4. Stationary means the procedure in which the common as well as the dependent function of probability distribution are diachronically invariable.
5. Port of Rotterdam (1991), "*Predictions on the goods flow through the Rhine Estuary ports in 1995, 2000 en 2010-model GSM-6*". This model consists of an application in MS-Excel environment, which takes the past demand of a kind of commodity (such as coal, electronic parts, etc.), by total commodities.
6. Dummy variables consist of factors referring to container handling that were impossible to quantify.
7. The coefficient of linear determination (R^2) is a positive number less than 1 and expresses the percentage of variation of the dependent variable which is explained from the independent variable.
8. The index utilization rate (UR) measures the relationship between the realized demand and the maximum demand that ports can serve. The value range of this index is $0.00<UR<1.00$. If the index has a value less than 0.50, it means that the port does not exhaust its capacity and a suitable customer attraction scheme is necessary because the port is in position to serve higher demand. If the index moves near to 0.90, this means that the port must increase its infrastructure (new terminals, new quays, new surfaces, etc.), to increase the total supply so that it can serve the developed demand. When the index is near to 1.00 the port is saturated and it is difficult to have any further development. Direct actions are required in order for the port to immediately increase the total supply.
9. According to the Sturges rule, the number of equal classes λ, is determined from the equation: $\lambda=1+3.3\log N$, where N is the number of observations.

TABLE 1: Pearson correlation indexes

	R	Prob
AEP	0,95647	0,0001
PEOPLE	0,91422	0,0001
AEPK	0,97169	0,0001
PRICE	0,95928	0,0001
ANERGIA	0,95979	0,0001
AEPT	0,95033	0,0001

SOURCE: Results of our analysis.

TABLE 2: Characteristics of model with all the independent variables

VARIABLE	PARTIAL R^2	MODEL R^2	Cp	F	Prob>F
AEPK	0,9457	0,9457	6,09	330,7	0,0001
ANERGIA	0,0086	0,9542	4,45	3,67	0,0832
DUM	0,0040	0,9582	4,76	1,62	0,2208
AEP	0,0032	0,9614	5,40	1,34	0,2647
P	0,0062	0,9676	4,77	2,86	0,1113
PEOPLE	0,0014	0,9690	6,17	0,63	0,4404

SOURCE: Results of our analysis.

TABLE 3: Results of SAS program, regression models for dependent variable TOTTEU

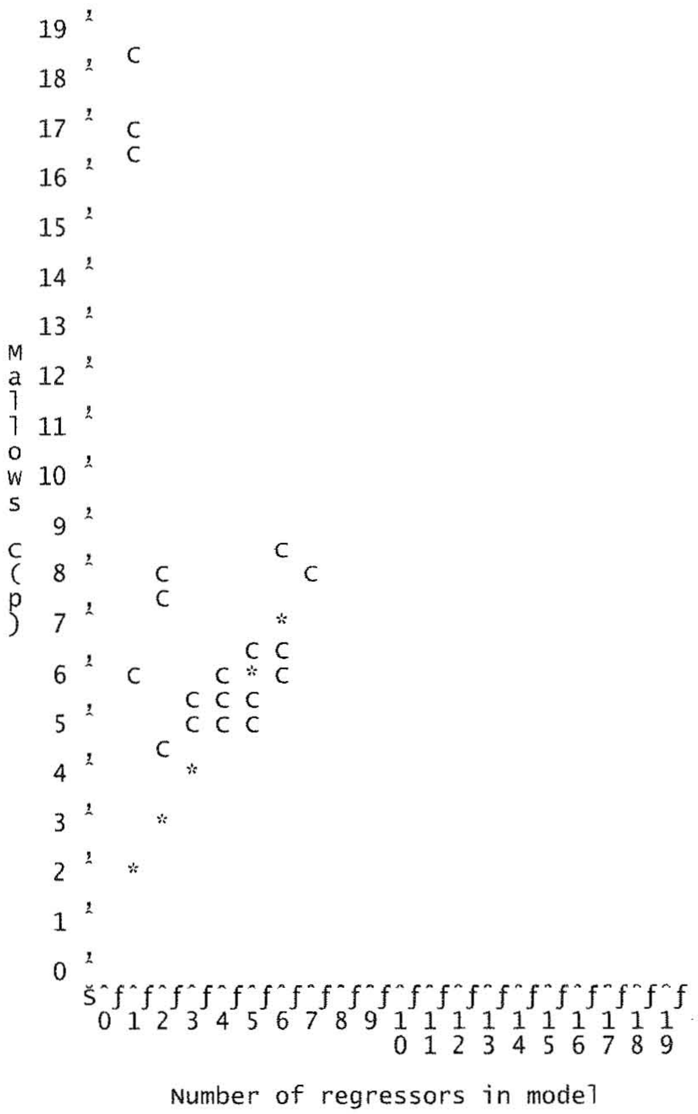
Number in Model	R^2	C(p)	Variables in Model
1	0.94566307	6.09033	AEPK
1	0.92142913	16.38848	ANERGIA
1	0.91969841	17.12394	P
1	0.91662719	18.42905	AEP
2	0.95422257	4.45300	ANERGIA AEPK
2	0.95354501	4.74092	P AEPK
2	0.94722655	7.42594	PEOPLE AEPK
2	0.94623390	7.84776	AEP AEPK
3	0.95819663	4.76423	ANERGIA AEPK DUM
3	0.95779288	4.93580	P AEPK DUM
3	0.95733880	5.12876	P AEPK AEPTR
3	0.95641854	5.51982	PEOPLE ANERGIA AEPK
4	0.96271335	4.84486	P AEPK AEPTR DUM
4	0.96141846	5.39512	AEP ANERGIA AEPK DUM
4	0.96087720	5.62513	P ANERGIA AEPK DUM
4	0.96049053	5.78944	PEOPLE P ANERGIA AEPK
5	0.96760259	4.76719	AEP P ANERGIA AEPK DUM
5	0.96615563	5.38207	PEOPLE P ANERGIA AEPK DUM
5	0.96606617	5.42009	P ANERGIA AEPK AEPTR DUM
5	0.96312362	6.67052	AEP P AEPK AEPTR DUM
6	0.96899915	6.17372	PEOPLE AEP P ANERGIA AEPK DUM
6	0.96790464	6.63883	PEOPLE P ANERGIA AEPK AEPTR DUM
6	0.96787176	6.65281	AEP P ANERGIA AEPK AEPTR DUM
6	0.96338136	8.56099	PEOPLE AEP P ANERGIA AEPTR DUM
7	0.96940797	8.00000	PEOPLE AEP P ANERGIA AEPK AEPTR

TABLE 4: Results of SAS program, model statistics according to Mallow's method

OBS	_DEPVAR_	_RMSE_	INTERCEP	PEOPLE	AEP	P	ANERGIA	AEPK	AEPTR	DUM	TOTTEU	_IN_	_P_	_EDF_	_RSQ_	_CP_
1	TOTTEU	51652.93	135577.56	.	.	.	.	0.56429	.	.	-1	1	2	24	0.94566	60.903
2	TOTTEU	62112.39	27443.04	.	.	.	1670.93	.	.	.	-1	1	2	24	0.92143	163.885
3	TOTTEU	62792.75	61363.96	.	.	291.598	.	.	.	.	-1	1	2	24	0.91970	171.239
4	TOTTEU	63982.27	104903.11	.	0.031337	.	.	.	.	.	-1	1	2	24	0.91663	184.290
5	TOTTEU	48709.50	93747.57	.	.	.	580.10	0.37851	.	.	-1	2	3	23	0.95422	44.530
6	TOTTEU	49068.66	106582.08	.	.	97.485	.	0.38552	.	.	-1	2	3	23	0.95355	47.409
7	TOTTEU	52299.29	-526740.77	0.06822	.	.	.	0.50827	.	.	-1	2	3	23	0.94723	74.259
8	TOTTEU	52788.86	130714.25	.	0.003890	.	.	0.49672	.	.	-1	2	3	23	0.94623	78.478
9	TOTTEU	47896.68	92676.89	.	.	.	742.17	0.31588	.	-42522.55	-1	3	4	22	0.95820	47.642
10	TOTTEU	48127.43	108182.52	.	.	129.510	.	0.31556	.	-44563.34	-1	3	4	22	0.95779	49.358
11	TOTTEU	48385.62	109809.19	.	.	137.659	.	0.51145	-211.183	.	-1	3	4	22	0.95734	51.288
12	TOTTEU	48904.71	1272236.57	-0.12393	.	.	921.40	0.37097	.	.	-1	3	4	22	0.95642	55.198
13	TOTTEU	46627.37	112099.41	.	.	179.886	.	0.45072	-242.348	-50509.81	-1	4	5	21	0.96271	48.449
14	TOTTEU	47430.10	86795.64	.	-0.012036	.	1060.06	0.42109	.	-50513.39	-1	4	5	21	0.96142	53.951
15	TOTTEU	47761.64	90719.82	.	.	78.412	473.82	0.25600	.	-50592.93	-1	4	5	21	0.96088	56.251
16	TOTTEU	47997.08	2068495.68	-0.20791	.	105.177	751.48	0.30148	.	.	-1	4	5	21	0.96049	57.894
17	TOTTEU	44888.36	80313.87	.	-0.018744	128.374	797.88	0.38168	.	-68179.40	-1	5	6	20	0.96760	47.672
18	TOTTEU	45879.84	2131275.19	-0.21471	.	132.546	864.52	0.20752	.	-52132.23	-1	5	6	20	0.96616	53.821
19	TOTTEU	45940.43	93990.05	.	.	127.966	494.29	0.39231	-249.010	-56963.35	-1	5	6	20	0.96607	54.201
20	TOTTEU	47890.87	113398.67	.	0.008530	166.953	.	0.44397	-366.017	-47417.68	-1	5	6	20	0.96312	66.705
21	TOTTEU	45451.37	1285655.57	-0.12655	-0.013965	147.543	945.54	0.32107	.	-64603.33	-1	6	7	19	0.96900	61.737
22	TOTTEU	46246.76	1473986.95	-0.14532	.	148.045	751.88	0.31395	-165.795	-55876.28	-1	6	7	19	0.96790	66.388
23	TOTTEU	46270.45	72081.34	.	-0.029498	122.760	969.64	0.35950	172.254	-73862.77	-1	6	7	19	0.96787	66.528
24	TOTTEU	49398.23	2499105.92	-0.25807	-0.035843	166.638	1708.11	.	546.441	-89747.62	-1	6	7	19	0.96338	85.610
25	TOTTEU	46855.08	1340574.96	-0.13339	-0.027027	141.626	1166.25	0.29032	213.343	-71449.21	-1	7	8	18	0.96941	80.000

FIGURE 1: Regression Models for Dependent Variable: TOTTEU

Plot of _CP_*_IN_. Symbol used is 'C'.
Plot of _P_*_IN_. Symbol used is '*'.



NOTE: 26 obs hidden.
This figure is an output of SAS software.

TABLE 5: Proposed model characteristics

1. ANALYSIS OF VARIANCE

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	898142976478	224535744120	103.277	0.0001
Error	21	34785790466	2174111904.1		
Total	25	932928766944			
Root MSE	46627.37291		R-square	0.9627	
Dep Mean	374526.00000		Adj R-sq	0.9534	
C.V.	12.44970				

2. PARAMETER ESTIMATES

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob>T	Variance Inflation
INTERCEP	1	112099	22393.77670	5.006	0.0001	0.000000
P	1	17.988647	6.76342596	2.660	0.0171	21.231336
AEPK	1	0.450724	0.14687487	3.069	0.0073	27.491230
AEPTR	1	-2.423477	1.66783194	-1.453	0.0455	33.038594
DUM	1	-50510	33259.93729	-1.519	0.0484	1.308384

3. CONSISTENT COVARIANCE OF ESTIMATES

ACOV	INTERCEP	P	AEPK	AEPTR	DUM
INTERCEP	107022780.95	1167.5315064	-193.1329871	-505.2279388	-65417139.48
P	1167.5315064	28.436004399	-0.012822104	-5.794506458	-78367.95862
AEPK	-193.1329871	-0.012822104	0.0218179172	-0.186464552	1205.1735945
AEPTR	-505.2279388	-5.794506458	-0.186464552	2.8892398765	5861.556667
DUM	-65417139.48	-78367.95862	1205.1735945	5861.556667	419894291.43

4. TEST OF FIRST AND SECOND MOMENT SPECIFICATION

DF: 25	Chisq Value: 9.0839	Prob>Chisq: 0.6958

5. OTHER STATISTICS

Durbin-Watson D	1.886	
(For Number of Obs.)	26	
1st Order Autocorrelation	0.098	

References

Box G.E.P and Jenkins G.M. (1976), "Time series analysis:Forecasting and control", (San Fransisco:Holden-Day).

Dagenais and Martin (1987), "Forecasting Containerized traffic for the Port of Montreal", Transportation Research A, vol 21A (1), p.p.1-16.

Daniel C. and Wood F. (1980), "Fitting equations to data", revised edition, (N.Y., John Wiley and sons, Inc).

Dinardo J, Johnston J (1996), "Econometric Methods", (McGraw Hill).

Doxiades Offices (1984), "Planning Study of Greek Ports, phase 2, forecasts and strategic, flows forecasts", Athens.

Drewry Shipping Consultans (1991), "Strategy and profitability in global container shipping", (London, U.K).

Drewry Shipping Consultans (2000), "Mediterranean Container Ports and Shipping, traffic growth versus terminal expansion, an impossible balancing act?", (DSC, London U.K).

Frankel Ernst (1987), "Port Planning and Development", (Wiley Interscience, USA).

Gallaway, Smith, Paul E (1961), "A quarterly econometric model of the United States", Journal of the American Statistical Association, JASA 56, p.p. 379-383.

Geraldo Araujo de Souza Junior, Beresford A and Pettit S (2003), "Liner Shipping Companies and Terminal Operators: Internationalisation or Globalisation?", Maritime Economics & Logistics, vol 5, p.p. 393-412.

Hayuth, Y, Pollatschek and Roll (1994), "Building a Port Simulator", Simulation 63, vol 3, p.p. 179-189.

Mallows C.L. (1973), "Some coments on Cp", Technometrics, vol 15, p.p. 661 – 675.

Intriligator M.D. (1982), "Econometric models, procedures and applications", volume B, (Athens, Greece).

Michalopoulos V.A. (1993), "Container traffic forecasts in Port of Piraeus Authority with ARIMA Procedure", 6th Greek Statistical Congress, Thessaloniki Greece.

Michalopoulos V. (1995), "Container Demand Model", 2nd Congress of SAS Users Group of Greece and Cyprus (SUGHE 95), p.p. 183-190.

Michalopoulos V.A. (1996), "A Management Information System for ship arrivals in Port of Piraeus", 9th Greek Statistical Congress, Xanthi Greece, p.p. 245 – 254.

Michalopoulos V.A. - Pardalis A. (1997), "Introduction of Probability Theory for container traffic estimation. Implementation in Greek Port

Container Terminals", 10th Greek Statistical Congress, Piraeus Greece, p.p. 385 – 400.

Michalopoulos V.A. (2006), "Port competition of container handling in the Mediterranean & the role of Port of Piraeus", PhD thesis approved by Maritime studies Dept of University of Piraeus, Piraeus Greece.

Ocean Shipping Consultans (1998), "Mediterranean containerisation: Growth prospects to 2010", (OSC, U.K).

Pardalis A. - Michalopoulos V.A. (1994) "The Container Traffic in Port of Piraeus in 21st century entrance", study for Research Center of University of Piraeus, Piraeus Greece.

Pardalis A - Michalopoulos V. (1996), "Evaluation of future demand of container traffic, the case of Piraeus", in proceedings of 'International Conference in Quantitative analysis', November 7-9, Piraeus.

Pardalis A. (1997), "Economics and Politics of Ports", (Interbooks publications, Greece).

Pardalis A and Chlomoudis K (2002), "Exploitation carriers of ports: private or public ports?", essays in honour of Professor Litsa Nikolaou - Smokovitis, offprint.

Pardalis A. - Michalopoulos V. A. (2003), "A proposed Procedure to calculate the future demand for transshipped containers: The case of Greek terminals", Cyprus Journal of Science and Technology, vol 3.3 (2003).

Sabrakos E. (2001), "Introduction of Economics of Transport", (Stamoulis publications, Piraeus Greece).

S.A.S. STAT (1990), User's Guide vol 2, (Cary NC, USA).

Smith S. (1987), "Tests of forecast accuracy and bias for country population projections", Journal of the American Statistical Association, JASA 82, p.p. 991-1003.

Sun N.C. and Bunamo (1973), "Competition for handling U.S. foreign trade cargoes: The Port of New York experience", Economic Geography, vol 49 (2) p.p. 156-162.

Thalassinos E. (1991), "Time Series Analysis: Box-Jenkins methodology", (Stamoulis publications, Piraeus Greece).

West M, Harrison P, Migon, Helio S (1985), "Dynamic generalized linear models and Bayesian forecasting", Journal of the American Statistical Association, 80, p.p. 73-83.

White H. (1980), "A heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity", Econometrics, vol 48, p.p. 817-838.